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EXPERIMENTAL STUDY ON STRENGTH AND DURABILITY OF CONCRETE WITH MARBLE AND GRANITE POWDER

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ABSTRACT

The waste generated from the industries cause environmental problems. Hence the reuse of this waste material can be emphasized. To produce low cost concrete by replacing fine aggregate with stone waste(marble and granite) and to reduce disposal and pollution problems due to the use of stone waste. It is most essential to develop low cost building materials from stone waste. The innovative use of stone waste in concrete by replacing fine aggregate with this material was the other alternative of the traditional concrete. Concrete mixtures were produced, tested and compared in terms of durability and strength to the conventional concrete. These tests were carried out to evaluate the mechanical properties for 7 and 28 days and durability properties. As a result, the compressive strength, flexural strength and split tensile strength is similar to that of control concrete by replacing of stonewaste (marble and granite) and permeability (12 hours) of concrete with granite is similar to control concrete, but concrete with marble is lower than (10%) of control concrete, permeability (3 hours) of concrete with waste (marble and granite) is lower (15%) than of control concrete. Keeping all this in view, the aim of the investigation is to study the behavior of concrete while replacing fine aggregate with waste and cement as a binder material in time and replacing of cement by fly ash (20%) as a binder material in another time for two water to binder ratio 0.61 and 0.5.

KEYWORDS: Compressive Strength, Flexural Strength, Split Tensile Strength, Permeability, Replacement of Fine Aggregate, Replacement of Cement

INTRODUCTION

Background

Marble/granite has been commonly used as a building material since the ancient times. The industry's disposal of the marble/granite powder material, consisting of very fine powder, today constitutes one of the environmental problems around the world. Marble / Granite blocks are cut into smaller blocks in order to give them the desired smooth shape. During the cutting process about 25% the original marble mass is lost in the form of dust. This mixture of slurry coming out during cutting is called stone waste. Use of stone waste in various engineering applications can solve the problem of disposal of stone waste and other purposes. Stone waste can be used in concrete to improve its strength and other durability factors. Stone waste can be used as a partial replacement of cement or replacement of fine aggregate and as a supplementary addition to achieve different properties of concrete.

The use of the replacement materials offer cost reduction, energy savings, arguably superior products, and fewer hazards in the environment. Concrete is a composite construction material composed of cement, aggregate

(generally a coarse aggregate made of gravels or crushed rocks such as limestone, or granite, plus a fine aggregate such as sand), water, and/or admixtures. Concrete is made by mixing: Cement, water, course fine aggregates and admixtures (if required). The objectives are to mix these materials traditionally to make concrete that is easy to: Transport, place, compact, finish and to give a strong and durable product. The proportionate quantity of each material (i.e. Cement, water and aggregates) affects the properties of hardened concrete. [1]

OBJECTIVE

This project aims to study the performance of concrete with respect to its strength and durability upon addition of marble and granite powder. This is achieved by casting of concrete cubes, beams and cylinders with two types of water to binder ratio with and without fly ash.

Hence the main Objectives are:

- To observe the variation of *compressive strength* of concrete upon addition of marble and granite powder.
- To observe the variation of *durability* of concrete upon addition of marble and granite powder.

LITERATURE REVIEW

- The author of [**Bahar Demire,2010**] proposed as in this experimental study, the effects of using waste marble dust (WMD) as a fine material on the mechanical properties of the concrete have been investigated. For this purpose four different series of concrete-mixtures were prepared by replacing the fine sand (passing 0.25 mm sieve) with WMD at proportions of 0, 25, 50 and 100% by weight.
- The author of [**Jayeshkumar Pitroda et al, 2012**] proposed as the advancement of concrete technology can reduce the consumption of natural resources and energy sources and lessen the burden of pollutants on environment. Presently large amounts of fly ash are generated in thermal industries with an important impact on environment and humans. In recent years, many researchers have established that the use of supplementary cementitious materials (SCMs) like fly ash (FA), blast furnace slag, silica fume, metakaolin (MK), and rice husk ash (RHA), hypo sludge etc. can, not only improve the various properties of concrete - both in its fresh and hardened states, but also can contribute to economy in construction costs .
- The author of [**M. Belachia et al, 2011**] proposed as the setting in discharge of waste of materials presents many problems (the place occupied by the sites of storage, the importance of the costs and the environmental impact. The industry of construction does not pose problems only at the end of the cycle of life of these products but also at the beginning it .It is then necessary to find means for the valorization and the re-use of this waste and consequently to find another source of the aggregates. The principal goal of these studies is to technically show the possibility of using the aggregates scrap marble like substitute in the hydraulic concrete.
- The author of [**AnkitNileshchandra Patel et al,2013**] proposed as , utilization of the stone dust in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. It is most essential to develop eco-friendly concrete from stone waste. In this research study the (PPC) cement has been replaced by stone waste accordingly in the range of 0%, 10%, 20%, 30% 40%, & 50% by

weight for M-25 grade concrete. Concrete mixtures were produced, tested and compared in terms of workability and strength to the conventional concrete.

- The author of [**Nutan C. Patel et al, 2013**] proposed as Marble waste is generally a high polluting waste due to both its high alkaline nature, and its manufacturing processing techniques, which impose a health threat to the surrounding. The quarries and processing plants are littered with large amounts of waste products deriving from extraction, sawing, polishing. At present, no significant activities are in place to recover and reuse the ultrafine CaCO3 dust combined in waste slurries of marble processing plants. It can be helpful to considering these calcareous particles as primary or secondary raw materials for use in other production. The main objective of this paper is to study the production process of the marble and during the production process how much waste is generated during the production process.

MATERIALS AND METHODOLOGY

Compressive Strength

The traditional methods of preparing the ends of cubes for compressive testing by using unbounded caps (neoprene pads) the 100mm *100mm*100mm cubes was chosen to fit the Universal testing machine with capacity 250 tonnes which is readily available in our testing labs. The maximum failure load applied to the specimen during the test is recorded.

Calculation

Compressive strength= (failure or ultimate load\cross sectional Area) MPa

Flexural Strength

Testing was conducted on 75 x 75 x 300 mm beam specimens. The test method adopted is as per IS–1959 *(Reaffirmed 1999*) Edition 1.2 (1991-07) two points loading methods. The load is applied through two similar rollers mounted at the third points of the supporting span that is spaced at 8 cm center to center; rollers are mounted in such a manner that the load is applied axially and without subjecting the specimen to any torsional stresses. The load is to be applied without shock and increasing continuously at a rate such that the stress increases at approximately 7kg/sq cm/min, which is at a rate of 180kg/min. The maximum failure load applied to the specimen during the test is recorded.

Calculation

The flexural strength of the specimen shall be expressed as the modulus of rupture f_b. $f_b = {pl}/{bd^2}$

b= measured width in cm of the specimen,

d= measured depth in cm of the specimen at the point of failure,

I= length in cm of the span on which the specimen was supported,

P= maximum load in kg applied to the specimen.

Split Tensile Test

The tensile strength of concrete testing was done as per IS-5816 1999 Splitting Tensile Strength of Concrete Method of Test This test often referred to as the split-cylinder test, indirectly measures the tensile strength of concrete by compression testing machine by placing the cylinder longitudinally . The load configuration creates a lateral tensile stress in the cylinder across the vertical plane of loading. IS -5816 indicates that the maximum tensile stress can be calculated based on the bellow equation. In this equation, *p* is the load applied to the cylinder, *I* and *d* are the length and diameter, and *fct* is the tensile stress. Rate of loading 1.2-2.4 N/mm2, $fct = \frac{2p}{\pi l d}$

Water Permeability

The splitting longitudinal section of a cylinder which is immersed in water permeability apparatus for 12 and 3 hours under pressure of 6 kg/cm ^{2} is taken as water permeability. Immediately after the splitting of the cylindrical sample the water penetration depth is marked with a marker and the penetration depth is measured at different location with minimum of four to six points. The average depth in mm is taken as the water penetration depth.

Composition and Properties of Materials Used

The properties of materials used for this research are listed below.

- **Binder or Cementitious Materials**: Cement used is OPC 43 conforming to IS 8112 and specific gravity was 3.14.used as binder throughout the project. In addition to this Fly ash with specific gravity of 2.2 are used as pozzolanic admixtures.
- **Water**: The water used throughout the test is potable water. Water reacts chemically with cement to form the cement paste, which essentially acts as the “glue” (or binder) holding the aggregate together .The reaction is an exothermic hydration reaction. The W/C ratio is an important variable that needs to be “optimized”. High ratios produce relatively porous concrete of low strength, whereas too low a ratio will tend to make the mix unworkable.
- **Aggregates**: Aggregates are usually described as inert “filler” material of either the fine or course variety. The shape, size density and strength of aggregate particles can vary significantly, and can therefore influence the properties of the concrete. Local natural river sand zone II with specific gravity of 2.62 is used as fine aggregate. Absorption capacity of sand is 1.2%. Crushed granite with maximum nominal sizes of 10mm and 20mm and specific gravity of 2.93 are used as coarse aggregate.
- **Admixture**: GLENIUM SKY 777, hyperplasticiser based on 2nd generation polycarboxylic ether (PCE) polymers, developed using nano-technology, has been in the whole experiment. It is free of chloride and low alkali and is compatible with all types of cements. Utilizing Rheodynamic Concrete technology, it provides a concrete mix with exceptional placing characteristics and accelerated cement hydration for early strength development and high quality concrete.
- **Marble Powder**: This powder was used in the casting of concrete in the form of slurry after determining its water absorption property appropriately. Its specific gravity is 2.23.

- **Granite Powder**:This powder was used in the casting of concrete in the form of slurry after determining its water absorption property appropriately. Its specific gravity is 2.15.

Mix Design

The capacity of mixtures used is of 100 litres per batch. The mix of o.o44m^3 or 44 litres per batch was followed for all batches. The table below shows the mix proportions for (1m3).

Table 1: Mix Design

Specimen Mark	Specific Gravities								
	1	3.14	2.2	-------	2.23	2.15	2.62	2.93	2.93
	Weight of the Materials (kg)								
	Water, w	Cement, c	Fly Ash, f	Water to Binder ratio(w/b)	Marble, m	Granite, g	Sand, s	Coarse Aggregate: 10 mm	Coarse Aggregate: 20 mm
AM-9	191	314	0	0.61	0	0	688	500	750
AM-11	191	270	68	0.61	0	0	684	481	725
AM-1	160	320	0	0.50	0	0	900	447	650
AM-6	160	275	69	0.50	0	0	723	495	750
AM-10	191	314	0	0.61	320	0	312	500	750
AM-12	191	270	68	0.61	320	0	308	481	725
AM-4	160	320	0	0.50	360	0	322	509	764
AM-5	160	275	69	0.50	360	0	300	495	750
AM-2	191	314	0	0.61	0	320	299	500	750
AM-3	191	270	68	0.61	0	320	295	481	725
AM-7	160	320	0	0.50	0	360	305	509	764
AM-8	160	275	69	0.50	0	360	300	490	738

RESULTS AND DISCUSSIONS

Compressive Strengths

Compressive strength is one of the most important properties of concrete. Below table and graphs are results of compressive strength in Mega Pascal (Mpa or N/mm^2) of the mixes that were used.

Table 2: Compressive Strengths

Specimen Mark	7 Days Strength (MPa)	28 Days Strength (MPa)
AM-9	20.3	27.0
AM-11	20.0	29.0
AM-1	27.6	39.2
AM-6	27.9	38.0
AM-10	19.7	26.3
AM-12	19.3	29.2
AM-4	23.7	34.8
AM-5	24.0	38.0
AM-2	18.9	27.9
AM-3	22.1	29.4
AM-7	32.8	37.7
AM-8	29.7	42.9

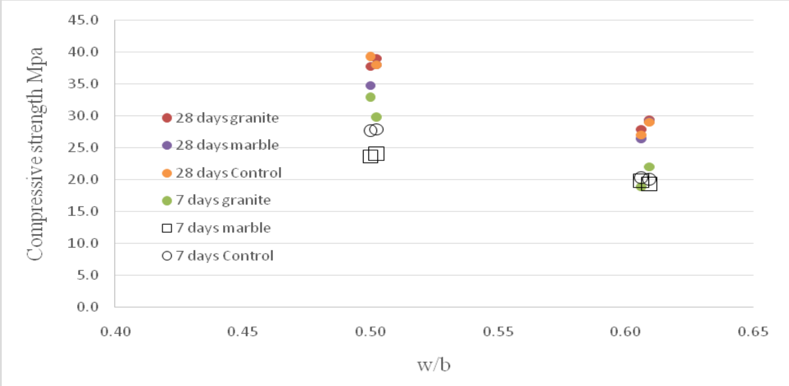

Figure 1: Compressive Strength vs. w/b Ratio

Flexural and Split Tensile Test

Knowledge of flexural and tensile value is required for the design of concrete structural element subject to transverse shear, torsion, shrinkage and temperature effects.

Table 3: Flexural Strength

Specimen Mark	Flexural Strength (MPa)	
	7 Days	28 Days
	Mean Flexural Strength (MPa)	Mean Flexural Strength (MPa)
AM-9	3.37	4.45
AM-11	3.19	4.70
AM-1	4.08	5.34
AM-6	4.27	6.58
AM-10	3.38	4.25
AM-12	3.06	4.38
AM-4	3.92	5.24
AM-5	3.76	6.08
AM-2	3.00	4.18
AM-3	2.59	4.75
AM-7	4.35	4.97
AM-8	3.52	5.93

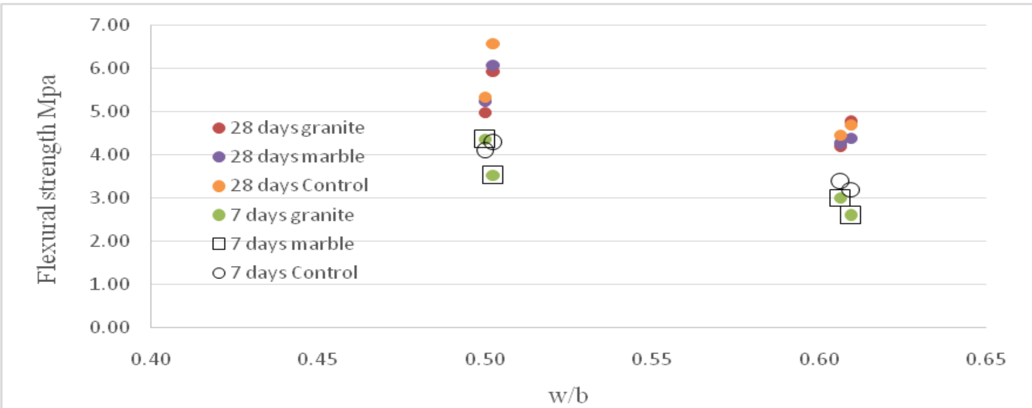

Figure 2: Flexural Strength vs. w/b Ratio

Table 4: Tensile Strength

Specimen Mark	Tensile Strength (MPa)	
	7 Days	28 Days
	Mean Tensile Strength (MPa)	Mean Tensile Strength (MPa)
AM-9	1.2	1.63
AM-11	1.5	2.20
AM-1	2.0	2.57
AM-6	2.3	2.74
AM-10	1.5	2.25
AM-12	1.8	2.26
AM-4	1.9	2.41
AM-5	1.6	2.73
AM-2	1.8	1.87
AM-3	1.5	2.10
AM-7	2.6	2.74
AM-8	1.9	3.05

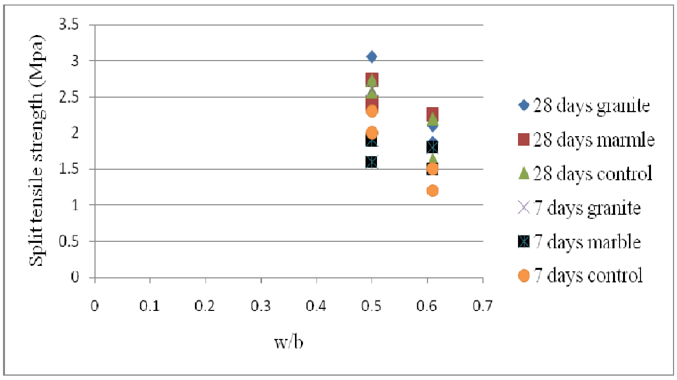

Figure 3: Split Tensile Strength vs. w/b Ratio

Durability Test

Durability of concrete is the ability of concrete to resist weathering action, chemical attack, and abrasion while maintaining its desired engineering properties.The following test. Water permeability is accelerated durability test, which are tabulated below .from the results it can be seen the behaviours of the concrete with marble powder and with granite powder in another time.

Table 5: Water Permeability

Specimen Mark	Water Permeability			
	12 Hours		3 Hours	
	Water Permeability Class	Split Stress (Mpa)	Water Permeability Class	Split Stress (Mpa)
AM-9	50.00	1.56	50.00	1.37
AM-11	34.00	1.94	25.83	2.65
AM-1	33.33	2.12	28.67	2.68
AM-6	20.00	3.71	22.83	3.52
AM-10	50.00	1.50	39.67	2.10
AM-12	17.67	2.81	30.67	2.58

Table 5: Contd.,

AM-4	35.67	2.34	30.67	2.75
AM-5	12.17	4.21	21.17	3.25
AM-2	50.00	1.50	38.00	2.10
AM-3	30.00	1.87	31.00	1.96
AM-7	30.33	3.12	21.50	3.18
AM-8	20.67	2.65	18.67	3.43

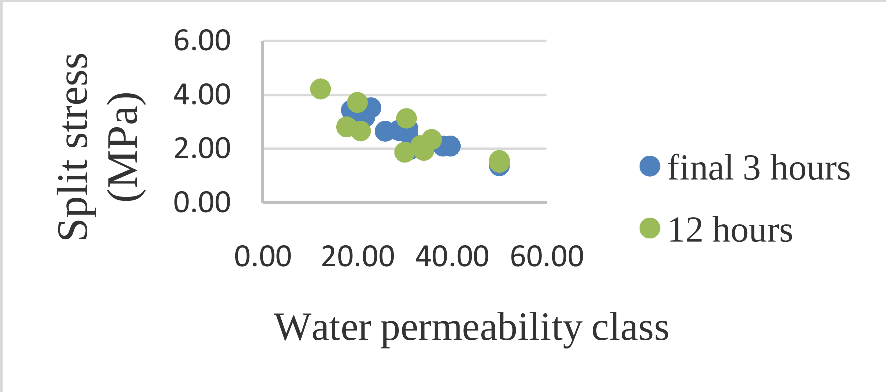

Figure 4: Water Permeability Class vs. Split Stress (MPa)

CONCLUSIONS

The experiments had been carried out with marble and granite powders in concrete. Compressive strength, flexural strength, split tensile strength and water permeability tests were conducted. The following conclusions could be made based on the experimental studies:

- Strength results showed consistent behavior at lower w/b ratio than higher w/b ratio.
- The compressive strength results of marble and granite concrete showed similar behavior with that of control concrete.
- Similar is the case for behavior between flexural and split tensile strength with w/b ratio.
- Permeability increased with decrease in compressive strength and decreased with decreasing w/b ratio.
- Permeability of marble concrete and granite concrete is lower than control concrete. This shows that marble and granite powder can enhance the durability of concrete.

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